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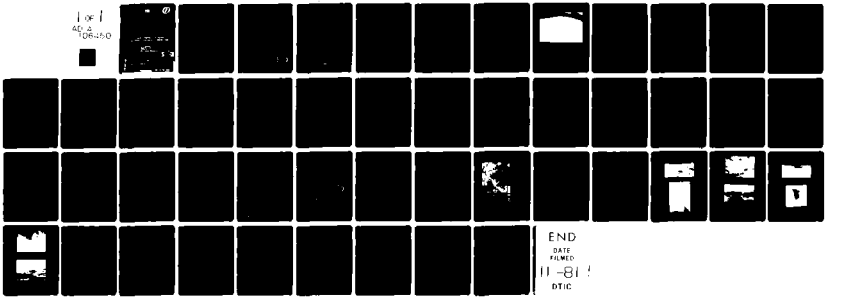

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Desoto Mining Co. Pit and Plant 'A' Dam (MO 30468)

This report presents the results of field inspection and evaluation of the Desoto Mining Co. Pit and Plant 'A' Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SIGNED

SUBMITTED BY: _____ 19 SEP 1980
Chief, Engineering Division — Date

SIGNED

APPROVED BY: _____ 22 SEP 1980
Colonel, CE, District Engineer — Date

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DESOTO MINING COMPANY

PIT AND PLANT "A" DAM

Washington County, Missouri

Missouri Inventory No. 30468

(6) **Phase I Inspection Report**

National Dam Safety Program,

Desoto Mining Co. Pit and Plant 'A' Dam (MO 30468, Mississippi - Kaskaskia - St. Louis Basin. Washington County, Missouri. Phase I Inspection Report.

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

(9) Final rept.,

(15) DACW43-80-C-0066

(10) Richard /Berggreen
Jean-Yves /Perez

Under Direction of

St Louis District, Corps of Engineers

(12) 511

for

Governor of Missouri

(11) Sep[redacted]80

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Desoto Pit and Plant "A" Dam
State Located	Missouri
County Located	Washington
Stream	Turkey Creek
Date of Inspection	5 June 1980

Desoto Mining Company Pit and Plant "A" Dam, Missouri Inventory Number 30468, was inspected by Richard Berggreen (engineering geologist), David Hendron (geotechnical engineer), and Sean Tseng (hydrologist). The dam is an active barite tailings dam.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide an expeditious identification, based on available data and a visual inspection, of those dams which may pose hazards to human life or property. In view of the limited scope of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers, has classified this dam as a high hazard dam; we concur with this classification. The estimated potential damage zone extends approximately 21 mi downstream of the dam. Within the first 7 miles of the potential damage zone are seven dwellings and a state highway, numerous dwellings are located in the next 14 miles.

Pit and Plant "A" Dam is in the intermediate size classification based on its maximum height of 76 ft and maximum storage capacity of approximately 2670 ac-ft.

Our inspection and evaluation indicate the dam is in fair to good condition. There is no designed spillway at this dam. This is considered a deficiency. Runoff from the dam crest roadway is directed toward the downstream face of the dam and has caused some minor erosion on the face of the embankment. The downstream face of the dam appears excessively steep and would be severely eroded if the dam were overtopped. At the time of our inspection, the tailings level only 2 to 3 ft below the dam crest at several locations.

D

Hydraulic/hydrologic analyses indicate the informal spillway at the southeast end of the dam will pass the PMF without overtopping the embankment. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. Substantial flood flows can be expected to erode the spillway, but its location, far from the maximum section of the dam, indicate this erosion should not pose a hazard to the embankment. The 1 percent probability-of-occurrence precipitation event will also be passed by the spillway without overtopping the dam embankment.

It is recommended a periodic inspection and monitoring program be initiated at this dam. This program should include:

1. Inspection of the embankment to identify areas of slope instability such as slumps, and erosion of the face of the dam.

2. Monitoring seepage at the left abutment and near the toe of the dam to identify changes in the volume of flow or in the turbidity of the seepage water.

We further recommend that static and seismic stability analyses and seepage analyses be conducted by an experienced engineer to meet the standards set forth in the recommended guidelines.

A hydrologic analysis should also be conducted to facilitate the design of spillway and discharge channel.

It is suggested the owner takes action on these recommendations without undue delay.

WOODWARD-CLYDE CONSULTANTS

Richard Berggreen

Richard Berggreen
Registered Geologist

Jean-Yves Perez, P.E.
Vice President

OVERVIEW

DESOTO MINING CO. PIT & PLANT A

MISSOURI INVENTORY NO. 30468

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DESOTO PIT AND PLANT "A" DAM - MISSOURI NO. 30468

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DESOTO PIT AND PLANT "A" DAM, MISSOURI INVENTORY No. 30468

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of Desoto Pit and Plant A Dam Missouri Inventory Number 30468.

b. **Purpose of Inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted." (Chapter 3, Recommended Guidelines for Safety Inspection of Dams).

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams"; "Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188", National Program for Inspection of Non-Federal Dams, prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams" prepared by the St Louis District, Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** Desoto Pit and Plant A Dam is an active tailings dam. Its construction procedure and usage are typical of other barite tailings dam in the area. The unique nature of these tailings dams has a significant impact on their evaluation. A brief description of the general construction procedure and usage of Missouri barite tailings dams is necessary to understand the unique nature of these dams, and understand the differences between these dams and conventional water-retaining dams.

At the start of a barite mining operation in this area, a 10 to 20-ft high starter dam is usually first constructed across a natural stream channel. Generally the streams are intermittent so that construction is carried out in the dry. Trees and other vegetation are removed from the dam site and then a cutoff is often made to shallow bedrock. Locally obtained earth, usually a gravelly clay, is then placed to form the embankment. Compaction is limited to that provided by the equipment.

The barite ore is contained within the residual gravelly clay which is mined with earth-moving equipment. At the processing plant, the ore is washed to loosen and remove the soil. This water is obtained from the reservoir area behind the dam. The soil-laden, wash water (and water from other steps in the process) is then discharged into the reservoir. There, the soil is deposited by sedimentation and the water recycled. Another step in the process removes the broken gravel-sized waste which is called "chat".

As the level of the fine tailings increases, the dam is raised. The usual method is to dump chat on the dam crest. The chat is spread over the crest so that a relatively constant crest width is maintained as the dam is raised. Generally the crest centerline location is also maintained. However, the crest centerline location may migrate upstream if there is insufficient chat available and downstream if an excessive quantity of chat is available. The latter is uncommon, because it is indicative of a poor ore deposit.

This method of construction results in embankment slopes which are close to the natural angle of repose for the chat. They can be considered to be near a state of incipient failure.

A large quantity of water is required for a barite processing, on the order of 2000 to 5000 gal/min. Thus, it has been the operators' practice to construct the dam so that all inflow to the reservoir is recycled in order to have sufficient water for the operation. The result is that formal spillways or regulating outlets are generally not constructed. In most cases, a low point on or near the dam is provided for overflow, should the storage capacity be exceeded.

The fine tailings typically fill more than 80 percent of the total storage volume. This results from the operator's practice of maintaining only a 2 to 5 ft elevation differential between the level of the tailings and the dam crest. The differential is usually greater further away from the discharge point and also typically further away from the dam.

The geotechnical characteristics of the fine tailings are somewhat similar to recent lacustrine clay deposits. Where the tailings have been continuously submerged, they have a very soft consistency and high water contents. When evaporation causes the water level to recede and the tailings are exposed, a stiff crust forms as the tailings dry out. Below the crust, the tailings retain their soft consistency for long periods of time. The consistency is very gradually modified by a slow process of consolidation.

Pit and Plant A Dam is generally representative of barite tailings dams. The embankment is composed of chat but appears wider at the crest than most other dams. The downstream slope is very steep and the upstream slope is covered by the fine tailings. There are no regulating outlets other than the ungated, earth-lined spillway. The spillway is not a designed feature, and consists of a mined-out, low area at the southeast end of the dam.

b. **Location.** The dam is located about 2 mi east of Richwoods, Washington County, Missouri, see Fig. 1. It is on an unnamed tributary of Ditch Creek within Washington County Barite District, Survey #1855, on the USGS Richwoods NE 7.5 minute quadrangle map.

c. **Size classification.** The dam is classified as intermediate size due to its 76 ft height and storage capacity of approximately 2670 ac-ft.

d. **Hazard classification.** The St Louis District has classified this dam as a high hazard dam; we concur with this classification. The damage zone estimated by the SLD extends 21 mi downstream. Missouri Highway H and seven occupied dwellings are located in the first 7 mi, with numerous dwellings in the remaining 14 mi.

e. **Ownership.** We understand the dam is owned by Desoto Mining Co, Box 35, Richwoods, Missouri, 63071. Correspondence should be addressed to Mr Durward Spees.

f. **Purpose of dam.** The dam was constructed to impound fine barite tailings produced by washing barite ore mined in the vicinity. Wash water is discharged into the impoundment where the fine-grained particles settle out. After sedimentation is complete, clear water is reused and returned to the impoundment.

g. **Design and construction history.** The owner has no record of the design and construction of the dam. The dam is currently being constructed by end-dumping clean, well-graded, coarse tailings (approximately minus 3/4 in. size) along the crest of the existing embankment. The tailings from the barite washing operations pond against the coarse tailings. The height of the dam is increased in three to five foot lifts as the height of tailings increases. Compaction is limited to the roadway along the dam crest, and is limited to the truck-traffic hauling the chat.

h. **Normal operating procedures.** No operational records were found for this facility.

1.3 Pertinent Data

a. **Drainage area.** approximately 0.75 mi^2

b. **Discharge at damsite.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A

Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	3090 ft^3/sec at el 859.6
Total spillway capacity at maximum pool elevation	3090 ft^3/sec at el 859.6

c. **Elevation (ft above MSL).**

Top of dam	858 to 876
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	N/A
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Toe of dam at maximum section	790
Maximum tailwater	N/A

d. **Reservoir.**

Length of maximum pool	approximately 4400 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	N/A
Flood control pool	N/A
Design surcharge	N/A
Top of dam	2670 (this volume does not include volume of tailings)

f. **Reservoir surface (acres).**

Top of dam	140 at el 858
Maximum pool	approximately 180

Flood control pool	N/A
Recreation pool	N/A
Spillway crest	140 at el 858

g. **Dam.**

Type	Tailings
Length	3570 ft
Height	76 ft
Top width	50 to 55 ft
Side slopes	D/S, 1.5 (H) to 1(V); U/S, unknown
Zoning	Unknown (probably none)
Impervious core	Unknown (probably none)
Cutoff	Unknown (probably trench to shallow rock)
Grout curtain	Unknown (probably none)

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	N/A

i. **Spillway.**

Type	Uncontrolled, unlined earth in mined-out area
Length of weir	approximately 550 ft
Crest elevation	858 ft
Gates	None
U/S channel	None
D/S channel	Unlined earth through mined-out area

j. **Regulating outlets.** None

SECTION 2
ENGINEERING DATA

2.1 Design

No design drawings or other design data are known to exist.

2.2 Construction

No construction records are known to exist. Typical construction techniques are presented in Section 1.2a.

2.3 Operation

No operation records are known to exist.

2.4 Evaluation

a. **Availability.** There were no engineering data available.

b. **Adequacy.** Insufficient data were available to determine the adequacy of the design.

Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency that should be rectified. These analyses should be performed by an engineer experienced in the design and construction of dams. Further, these seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. **Validity.** Not applicable.

2.5 Project Geology

The dam site lies on the northern flank of the Ozark structural dome. The regional dip is to the north. The bedrock in the area is mapped as Cambrian Age, Eminence and Potosi Dolomite Formations on the Geologic Map of Missouri (Fig. 4). The Potosi Formation typically contains an abundance of quartz druse characteristic of chert bearing formations. The Eminence Formation conformably overlies the Potosi Formation, and contains less quartz and chert.

The soil at the dam site is a dark red-brown, very plastic, residual clay (CH), characteristically developed on the Potosi Formation. It is locally overlain by a soil profile consisting of 1 to 5 ft of silty loess (CL-ML). The area is mapped on the Missouri General Soils Map as Union-Goss-Gasconade-Peridge Association.

The Richwoods Fault zone lies approximately 1-1/2 mi south of the dam site and is mapped on the Structural Features Map of Missouri (1971) as discontinuous for approximately 19 mi, in a WNW-ESE direction. The Ditch Creek Fault System is located about 3 mi northeast of the site and is mapped on the Structural Features map as approximately 11 mi long, paralleling the Redwoods Fault zone. The Ditch Creek System is mapped as north side down; the Richwoods fault is mapped as north side up. These faults are not in a seismically active area, and are not considered to pose a significant hazard to the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** Pit and Plant "A" Dam was inspected on 5 June 1980, without the owner's representative present. This inspection indicated the dam was in fair to good condition.

b. **Dam.** The retaining embankment consists of coarse tailings locally referred to as "chat". This material is a cohesionless, permeable sandy gravel (GW, SW). Much of the material on the surface of this dam appears to consist of very coarse, clean quartz sand. The embankment is nearly barren of vegetation due to lack of fines to hold water. Chat has been dumped on the crest by trucks, producing slopes on the face of the dam which have an angle of 33 to 35 degrees with the horizontal, which is probably close to the natural angle of repose for this material.

The dam crest is 50 to 55 ft wide, considerably wider than is typical of tailings dams in the area. As the crest has been widened, the slopes have encroached on trees at the toe of the dam. Trees, up to 24 in. in diameter, are growing in the embankment, although their trunks are buried as much as 15 ft in the chat.

There was no evidence of serious erosion, sinkhole development, settlement, slope instability, animal burrows, depressions or cracking at the time of the inspection. Minor erosion of the downstream face caused by runoff from the roadway crest was observed. The downstream slope of the dam is considered excessively steep, making long-term stability questionable.

Seepage was noted at the two locations shown on Fig. A1, Appendix A. Clear water was observed seeping near the left abutment at approximately 3 to 5 gal/min. The seepage into the pond at the toe of this dam appeared to come from the sides of the pond rather than the dam.

c. **Appurtenant structures.**

Spillway. This dam has no designed spillway. An area which will apparently act as an informal spillway is in a mined-out area at the southeast end of the dam. The area is unlined earth over apparently shallow bedrock. Some erosion can be expected during heavy flood flows. However, erosion should not pose a hazard to the main embankment due to the distance of the informal spillway from the maximum section.

d. **Reservoir area.** The majority of the impoundment storage volume consists of fine-grained tailings, a relatively impervious mixture of water saturated sand, silt and clay. Much of the tailings in the reservoir were above water level at the time of the inspection. The exposed tailings area supports a dense growth of small trees (primarily willow) and other low brush vegetation.

Slopes surrounding the reservoir are quite flat and estimated to be less than 10(H): 1(V). No indication of instability of the surrounding slopes was observed.

e. **Downstream channel.** The downstream channel at Pit and Plant A Dam flows through an irregularily mined-out area east of the dam and reservoir. Immediately below the spillway section is a depression which fills up before flow runs into downstream channel. It appears that runoff would flow to the small drainage east of the dam and would not be expected to cause any erosion along the embankment. However, the irregular topography in the spillway and discharge area makes this determination somewhat equivocal. The irregular topography, shallow gradient, and vegetation in this area indicate some obstruction may occur during flood flows. No evidence of previous overflow was noted during the visual inspection.

3.2 Evaluation

Our evaluation indicates the dam is in fair to good condition. There is no designed spillway or discharge channel for this facility. This is considered a deficiency. Runoff would flow through a mined out area which acts as an informal spillway and discharge channel. This area could become obstructed during flood flows. There is

no evidence of serious erosion, excessive seepage, sinkhole development, depressions or cracking. However, the downstream slope of the dam is considered excessively steep, making the long-term static stability questionable.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

There are no operating procedures for this dam.

4.2 Maintenance of Dam

Maintenance consists of raising the dam to maintain 2 to 3 ft elevation differential between the dam crest and the fine-grained tailings.

4.3 Maintenance of Operating Facilities

There are no operating facilities which require maintenance at the dam.

4.4 Description of Any Warning System in Effect

The inspection did not identify any warning system in effect at this dam.

4.5 Evaluation

There are apparently no maintenance or operational procedures in effect. The lack of regular maintenance and periodic inspection is considered a deficiency.

The feasibility of a practical warning system should be evaluated to alert downstream residents should potentially hazardous conditions develop during periods of heavy precipitation.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic design information was available for evaluation of the dam or the reservoir. Topographic maps of the project prepared in February, 1980 were supplied by Desoto Mining Company. Other dimensions of the dam and reservoir were measured and/or surveyed on the date of inspection or estimated from an advance print of the USGS Richwoods, NE, 7.5 min quadrangle map.

b. **Experience data.** No recorded rainfall, runoff, discharge, or pool stage data were available for this reservoir or dam.

c. **Visual observations.**

1. Watershed. Approximately 40 percent of the drainage basin consists of mined-out areas reclaimed by nature that are now forested. Another 10 to 15 percent is utilized as pastureland. The area of the impounded tailings is approximately 47 percent of the total drainage area of 0.75 mi^2.

2. Reservoir. The reservoir and dam is best described by the maps and photographs enclosed herewith. The purpose of the reservoir is to impound the tailings produced during the barite milling process.

3. Spillway. There is no formal designed spillway at this facility. The term "informal spillway" has been assigned to the low area to the south of the south end of the dam (see Figs. 3a and 3b). This overflow area has a moderate to high erosion potential as the stoney clay residual soil is only vegetated by grass, brush and small trees. This soil has been observed to be highly erodible when stripped of vegetation and exposed to high flow velocities.

4. Downstream channel. The channel downstream of the informal spillway flows through a mined-out depression to the east (bottom elevation 838). An extension of the original chat dam (constructed before disturbance by mining) extends to the southwest of Sta 28+90 (see Fig. 3a). This chat embankment constricts flow in the channel and will be eroded during high outflows. After passing the flow constriction, the outflow passes through areas of previous mining operations that have been vegetated by nature to varying degree. The vegetation in these areas indicate overflow may become retarded during flooding. Further downstream, the channel becomes an intermittent stream passing through mixed areas of forest and pasture.

5. Seepage. Seepage noted during the visual inspection is not hydrologically significant in the overtopping analysis.

d. **Overtopping potential.** The lack of a designed, formal spillway and discharge channel indicate a deficiency at this facility. It is recommended that a hydrologic analysis be conducted to facilitate the design of a spillway and discharge channel adequate to pass an appropriate design flood.

For the purpose of the overtopping analysis, the elevation of the top of the dam was taken as 858, the controlling elevation of the informal spillway. The chat embankment varies between elevation 858 at the right abutment to 876 near the left abutment. Overtopping was found to occur for virtually any substantial precipitation event. Overtopping, in this analysis, means outflow around the right (south) abutment through the informal spillway. The chat embankment itself will not be overtopped.

Hydraulic and hydrologic analysis indicate that all fractions of the PMF and the 1 percent probability-of-occurrence event overtop the dam through the informal spillway. The PMF is defined as the flood event that may be expected to occur from the most severe combination of meterologic and hydro logic conditions that are reasonably possible in the region.

The following overtopping data for selected precipitation events were computed for the dam, assuming no erosion of the spillway or dam embankment.

Precipitation Event	Maximum Reservoir W.S. Elev.	Maximum Depth Over Embankment ft	Maximum Depth Over Informal Spillway, ft	Maximum Overflow, ft^3/sec	Duration of Overflow, hrs
50% PMF	859.0	0	1.0	1490	48*
100% PMF	859.6	0	1.6	3090	48*

*Since the starting water surface elevation is at the informal spillway crest elevation, the duration of overtopping will always be approximately equal to the storm duration.

Details of the hydrologic and hydraulic analyses are given in Appendix B.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** Visual observations of conditions which are judged to adversely affect the structural stability of this dam are reported in Section 3. These conditions include the lack of a designed spillway and discharge channel, two areas of seepage and the steep downstream face of the embankment.

b. **Design and construction data.** No design or construction data relating to the structural stability of the dam were available. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be corrected to conform with recommended guidelines.

c. **Operating records.** No appurtenant structures requiring operation exist at this dam.

d. **Post construction changes.** Construction of the dam is continuing with the addition of coarse tailings to the crest of the dam. No information exists concerning the owner's plan for final configuration of the dam. As the height of the dam increases, the risk of failure of the dam and the consequence of failure increase. There are no analyses or other data available to quantitatively evaluate the present or projected future stability of the dam.

e. **Seismic stability.** The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. Since no static stability analysis is available for review, the seismic stability cannot be evaluated. However, as the tailings are fine-grained saturated materials and the retaining embankment consists of loose, granular material, it should be expected that substantial deformation or failure of the embankment and reservoir could occur in the event of a severe seismic event.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, Desoto Pit and Plant A Dam is judged to be in fair to good condition. The lack of a designed spillway, very steep downstream slope, lack of maintenance, and lack of periodic inspections are the primary reasons for this judgment.

As a consequence of the widely-used construction procedure, the downstream slopes of the tailings dams are placed at or near the angle of natural repose for the "chat" material. This results in slopes that are very steep and exist in a state close to incipient failure with safety factors close to 1.0. These slopes will only remain stable, if they are protected against potential harmful changes, among which are:

1. Overtopping by water

2. Higher pore pressures (or seepage forces)

3. Undercutting of the toe of the slope by erosion or mining activity

4. Increase in the height of the slope (applicable to active operations)

5. Harmful effects of vegetation (particularly tree roots)

6. Liquefaction (such as may result from a seismic event).

The first five changes are subject to control by owners and operators and must receive careful attention in order to maintain stable and safe dam embankments. The sixth influence represents a risk the magnitude of which is not well understood without further study.

The stability of the dam increases over a period of time due to consolidation of the impounded tailings. If no tailings are added to the impoundment for a period of time (as if the facility was abandoned), they consolidate and settle. The lateral loads acting on the dam are therefore decreased, increasing the factor of safety against failure.

b. **Adequacy of information.** The lack of design data or stability and seepage analyses for the dam comparable to those recommended in the guidelines precludes an evaluation of the structural and seismic stability of the dam. This is considered a deficiency.

c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. Corrective actions should be initiated without undue delay.

d. **Necessity for Phase II.** In accordance with the Recommended Guidelines for Safety Inspections of Dams, the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed without undue delay are described in Section 7.2.b. It is our understanding from discussions with the St Louis District that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options which may be selected to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Remove the dam, or breach it to prevent storage of water.

2. Increase the height of dam and/or spillway size to pass the probable maximum flood without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure, and restrict human occupancy.

4. Enhance the stability of the dam to permit overtopping by the probable maximum flood without failure.

5. Provide a highly reliable flood warning system (generally does not prevent damage but avoids loss of life).

b. **Recommendations.** Based on our inspection of the Desoto Pit and Plant A Dam, it is recommended that further study be conducted without undue delay, to evaluate as a minimum:

1. Configuration and erosion potential of the existing informal spillway and discharge channel. This study should also evaluate the need to clear the discharge channel of obstructions to flood flows.

2. Grading of the roadbed on the crest of the dam to drain into the impoundment, in order to avoid erosion of the downstream face of the dam.

These studies and actions should be undertaken under the guidance of an engineer experienced in the design and construction of dams.

c. **O & M procedures.** A program of periodic inspections is recommended for the Desoto Pit and Plant A. This program should include, but not be limited to:

1. Inspection of seepage areas to identify increases in volume of seepage or turbidity (soil) in the seepage water.

2. Inspection of slopes to identify evidence of slope instability such as cracking or slumping of the embankment.

Records should be kept of the inspections and any required maintenance. All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of dams.

The evaluation of a practical and effective warning system is recommended to alert downstream traffic and residents should hazardous conditions develop at this dam.

REFERENCES

Allgood, Ferris P., and Persinger, Ivan, D., 1979, "Missouri General Soil Map and Soil Association Descriptions," US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.

Department of the Army, Office of the Chief of Engineers, 1977, EC 1110-2-188, "National Program of Inspection of Non-Federal Dams".

Department of the Army, Office of the Chief of Engineers, 1979, ER 1110-2-106, "National Program of Inspection of Non-Federal Dams".

Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations".

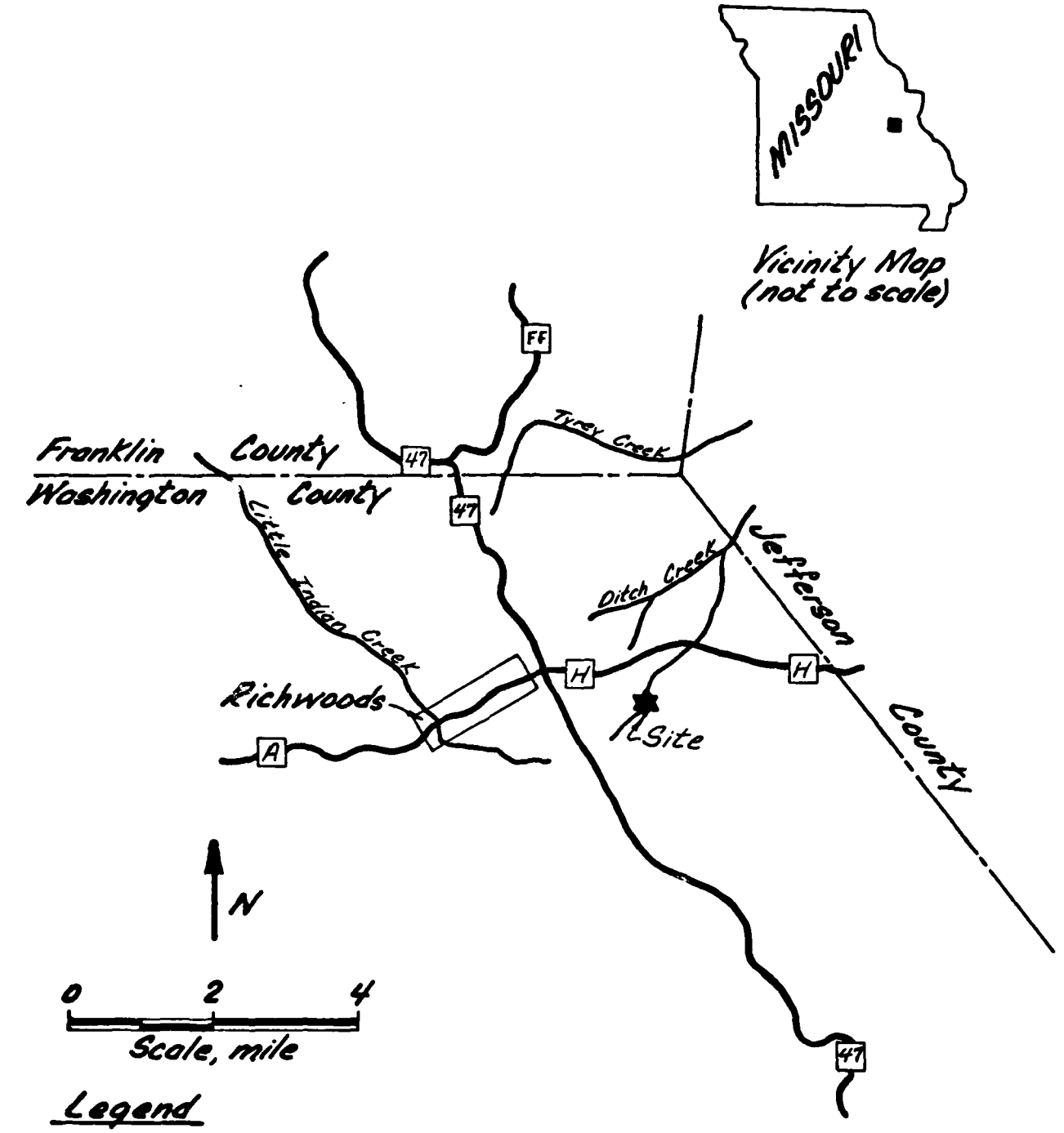
McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

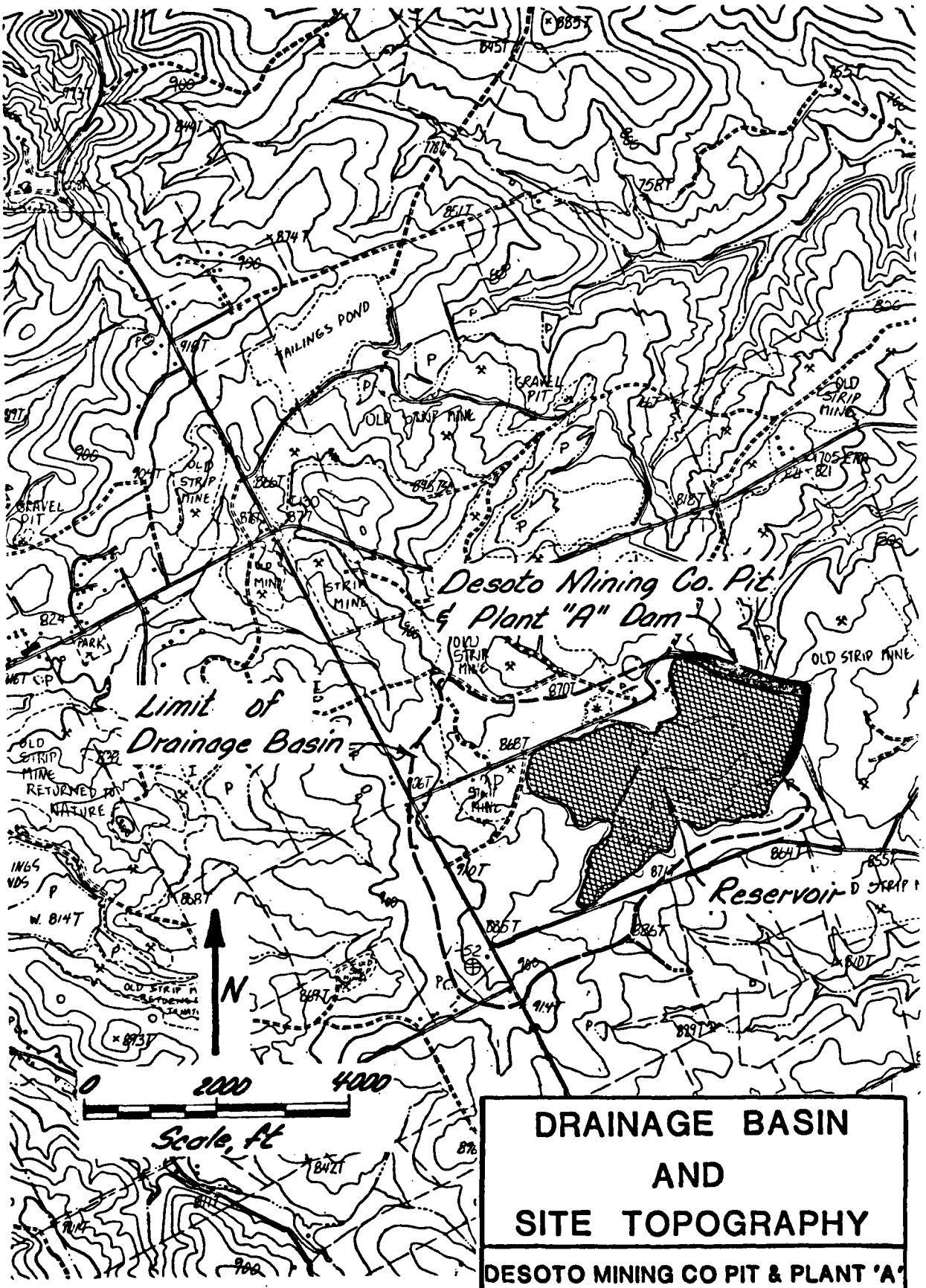
St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".

US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.

US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



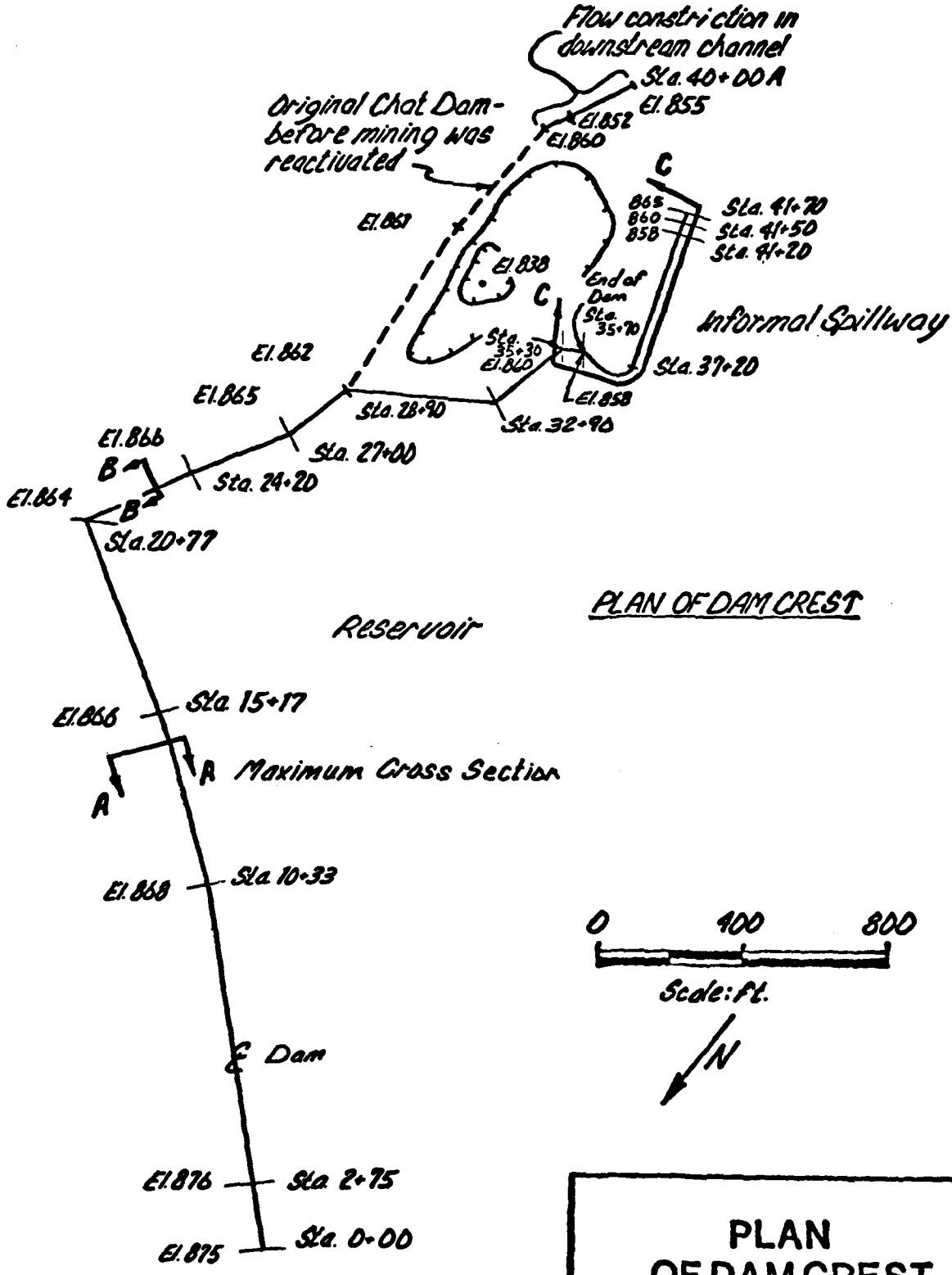
SITE LOCATION MAP	
DESOTO MINING CO PIT & PLANT 'A'	
MO. 30468	Fig. 1



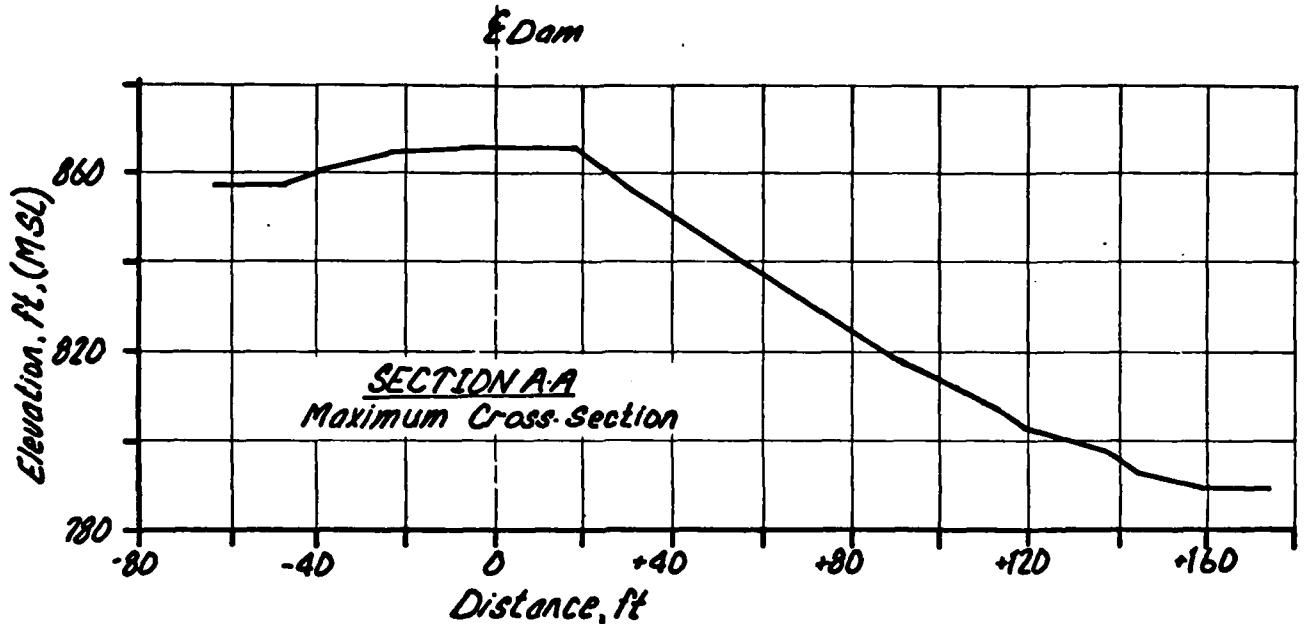
DRAINAGE BASIN AND SITE TOPOGRAPHY

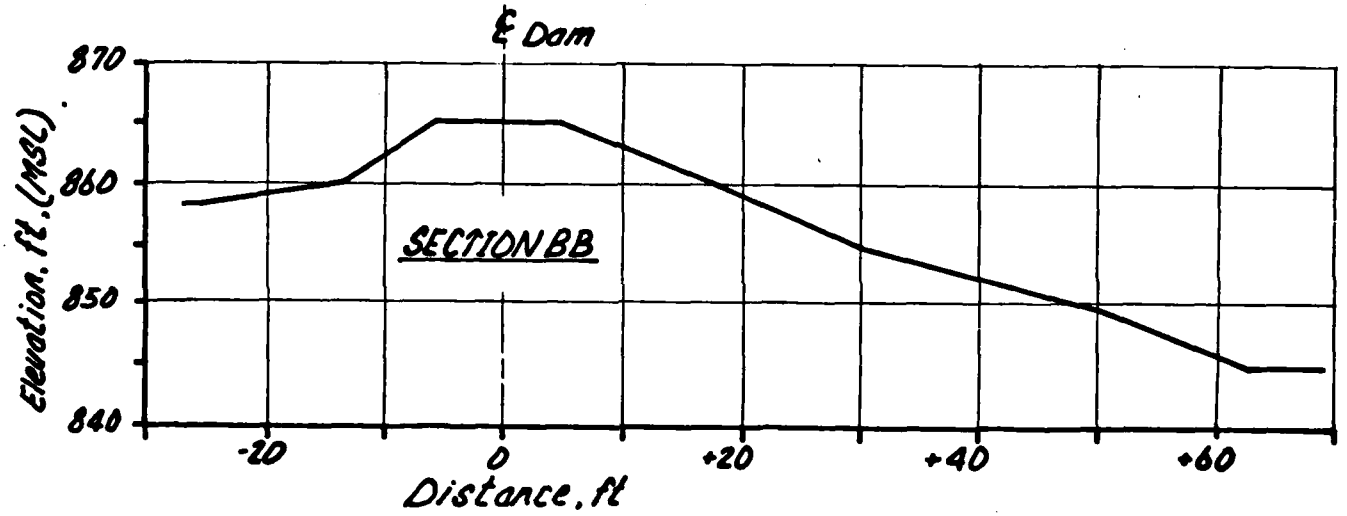
DESOTO MINING CO PIT & PLANT 'A'	
MO. 30468	Fig. 2

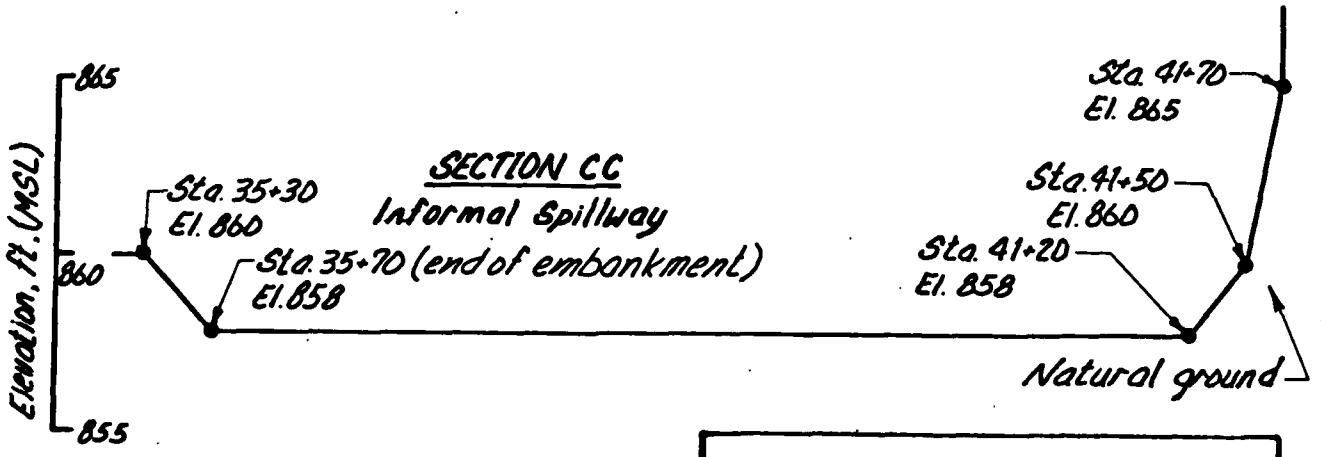
Topography from U.S.G.A. advance print Richwoods NE 7.5 minute Quarangle.



PLAN OF DAM CREST	
DESOTO MINING CO PIT & PLANT 'A'	
MO. 30468	FIG 3A







Note:

Profiles from 1 in. to 200 ft scale topo map supplied by Desoto Mining Co.

CROSS-SECTIONS OF DAM & SPILLWAY	
DESOTO MINING CO PIT & PLANT 'A'	
MO. 30468	FIG 3B

Legend

- Or — Roubidoux Formation
- Gasconade Dolomite
  - Gunter Sandstone Member
- Cep — Eminence Dolomite
- Potosi Dolomite
- Derby-Doerun Dolomite
- Ceb — Davis Formation
- Bonneterre Formation
  - Whetstone Creek Member
  - Sullivan Siltstone Member
- Reagan Sandstone (subsurface, western Missouri)
- Lamotte Sandstone
- Diabase (dikes and sills)
- St. Francois Mountains Intrusive Suite
- St. Francois Mountains Volcanic Supergroup

REGIONAL GEOLOGIC MAP

DESOTO MINING CO
PIT & PLANT 'A'

MO. 30468 | **Fig. 4**

APPENDIX A

Photographs

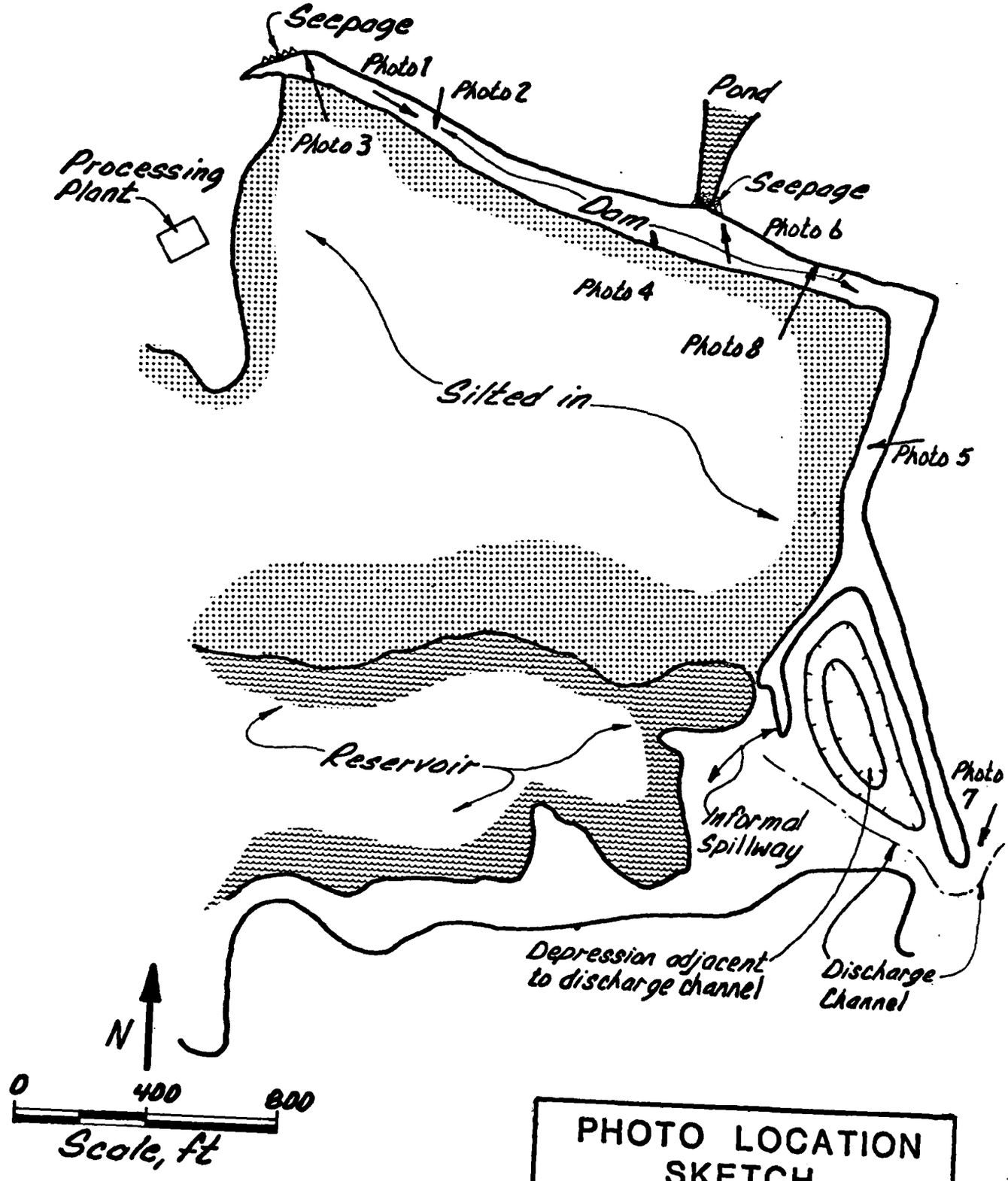


PHOTO LOCATION SKETCH	
DESOTO MINING CO PIT & PLANT 'A'	
MO. 30468	Fig. A-1

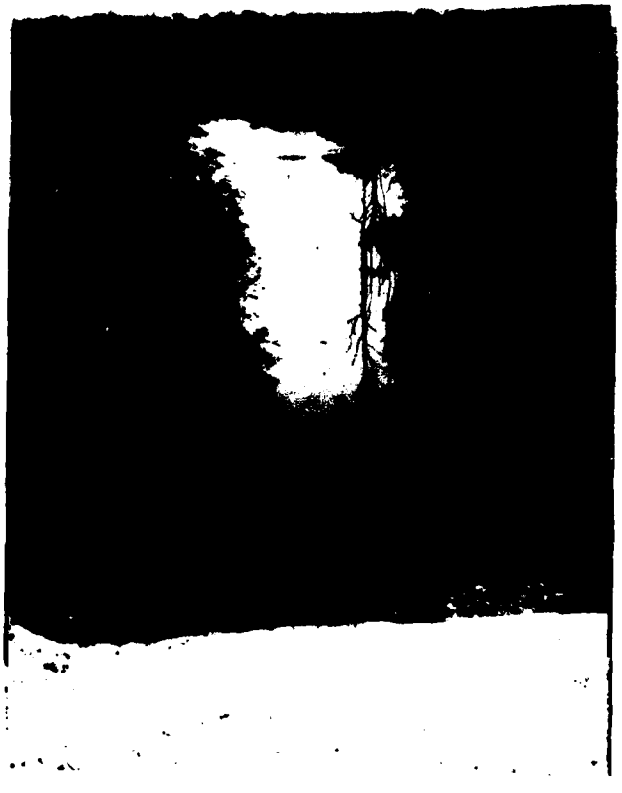
1. End-dumped tailings used to construct embankment. Note that widening the dam crest has resulted in the toe encroaching on the trees at the base of the dam. Looking east along crest of maximum section.

2. Predominantly coarse sand-sized tailings exposed on surface of embankment.

3. Seepage at junction of embankment with left (west) abutment. Looking northeast from crest of embankment.

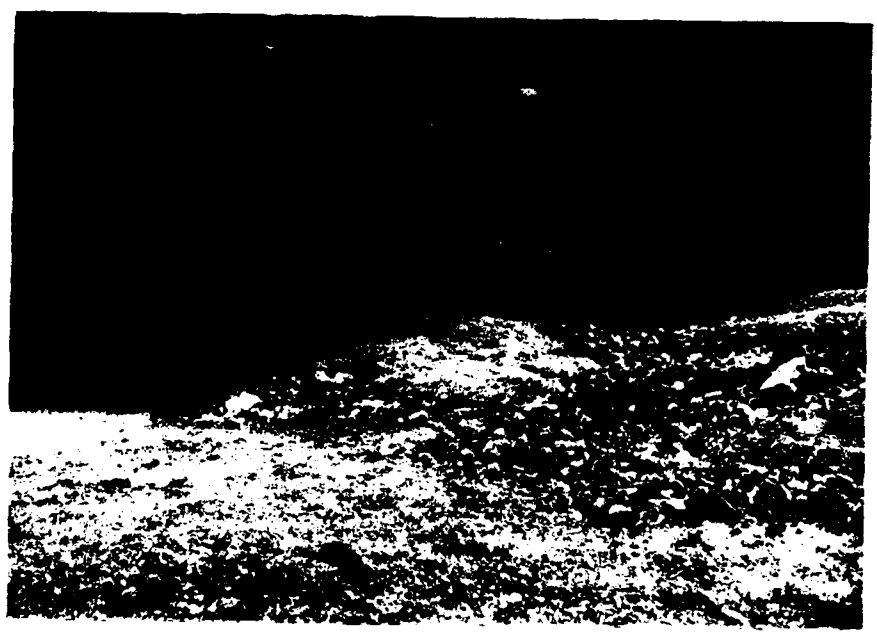
4. Gully eroded in downstream face of embankment by dumping water-saturated tailings from crest of dam.

5. Silted-in reservoir with dense growth of cattails and willow. Looking west from embankment.



6. Pond at toe of existing embankment.

7. Mined area comprising discharge area. Looking south. Dam out of picture to right.



8. Possible slump on face of dam. Looking north (downstream) from dam crest.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B

Hydraulic/Hydrologic Analyses

B.1 Procedures

a. **General.** The hydraulic/hydrologic analyses were performed using the "HEC-I, Dam Safety Version (1 Apr 80)" computer program. Inflow hydrographs were developed by applying various precipitation events to a synthetic unit hydrograph. The inflow hydrographs, thus obtained, were then routed through the reservoir and appurtenant structures by the modified Puls reservoir routing method used in the HEC-I program to determine overtopping potential.

b. **Precipitation events.** Various percentages including 100 percent of the Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The PMP was determined from regional charts prepared by the US Weather Bureau (1956). The 1 and 10 percent probability-of-occurrence events were provided by SLD.

c. **Unit hydrograph.** The Soil Conservation Service (SCS) unit hydrograph (SCS, 1971) for a storm duration of 48 hrs was used to develop the inflow hydrograph. The unit hydrograph was divided into 15 min increments.

d. **Infiltration losses.** The SCS curve number (CN) loss function was used to compute infiltration losses. Curve numbers were selected on the basis of antecedent moisture conditions in accordance with the guidelines, present land usage, and hydrologic soil group of the soils in the drainage basin.

e. **Lag time.** Lag time was computed by the SCS method (National Engineering Handbook, Equation 15-4).

B.2 Pertinent Data

a. **Drainage area:** 0.75 mi^2

b. **Lag time:** 1.15 hrs

c. **Hydrologic soil group:** C

d. **SCS curve numbers.**

1. For PMF: 89 (AMC III)
2. For 1 and 10 percent probability-of-occurrence events: 77 (AMCII)

e. **Storage.** Elevation-area data were developed by planimetering areas at various elevation contours on the 1 in. equals 200 ft contour maps supplied by Desoto Mining Company and the USGS advance print of Richwoods NE 7.5 minute quadrangle map. The data were entered on the $A and $E cards so that the HEC-I program could compute storage volumes.

f. **Outflow capacity.** The outflow capacity with regard to a spillway/discharge channel does not apply to this impoundment since no real spillway exists. Instead, outflow occurs over a long, low section of the natural hillside at the south end where the hill crest is approximately at the same elevation as the normal water surface elevation.

g. **Reservoir elevations.** For all fractions of the PMF, the starting reservoir elevation was the informal spillway crest elevation of 858 ft. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was also taken as 858 ft.

B.3 Results

The results of the analyses as well as the input values to the HEC-I program follow in this Appendix. Complete copies of the HEC-I output are available in the office of Woodward-Clyde Consultants, Chicago, Illinois.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  01 APR 80
**********
     1                A1       DAM NO. 30468 ,SOUTHEAST OF RICHWOODS,MISSOURI
     2                A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB NO. 79CH009
     3                A3       PROBABLE MAXIMUM FLOOD(PMF) ANALYSIS
     4                R    192         0        15        -0        -0        -0        -0        -0        -0        -0
     5                B1     5
     6                J      1         2         1
     7                J1   .50     1.00
     8                K      0  INFLOW                                                  1
     9                K1       DAM OVERTOPPING ANALYSIS
    10                M      1         2     0.75                                    1.0
    11                P      0.       26.      102.      120.      130.      140.
    12                T                                                        -1      -99              0.47
    13                W2             1.15
    14                X     -1     -.05         5
    15                K      1       DAM                                         1
    16                K1       PMF RATIO STORM FLOW CONTAINMENT ANALYSIS.
    17                Y                                  1
    18                Y1     1                                          -850.0
    19                $R     0.      139.      190.      229.
    20                $E   800.      858.      860.      865.
    21                $S   858.                2.7       1.5
    22                $D   999.       2.7       1.9
    23                $L     0.      550.      570.      520.     1240.     1680.
    24                $V   859.     858.2     858.5      860.      862.      865.
    25                K     99
```

Input Data
Various PMF Events
Desoto Pit and Plant A
MO 30468

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********

RUN  DATE: 04 SEP 81
     TIME: 07.17.37
```

DAM NO. 30468 ,SOUTHEAST OF RICHWOODS,MISSOURI
WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB NO. 79CH009
PROBABLE MAXIMUM FLOOD(PMF) ANALYSIS

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	MSTAN
192	0	15	-0	-0	-0	-0	-0	-0	-0

JOPER	NMT	LROPT	TRACE
5	-0	-0	-0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 2 LRTIO= 1

RTIOS= .50 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

DAM OVERTOPPING ANALYSIS

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW	0	-0	-0	-0	1	-0	-0	-0

HYDROGRAPH DATA

IHYDG	IUNG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.75	-0.	.75	1.00	-0.	-0	-0	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.	26.00	102.00	120.00	130.00	140.00	-0.	-0.

LOSS DATA

LROPT	STRKR	ULTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-99.00	-0.	.07

CURVE NO = -89.00 HETNESS = -1.00 EFFECT CN = 99.00

UNIT HYDROGRAPH DATA
TC= -0. LAG= 1.15

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 25 END-OF-PERIOD ORDINATES, TC= -0. HOURS, LAG= 1.15 MIN= 1.00

Input Data
Various PMF Events
Desoto Pit and Plant A
MO 30468

RECESSION DATA

STRTQ= -1.00 QRCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 25 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= 1.15 VOL= 1.00

25.	95.	181.	259.	284.	268.	228.	170.	118.	85.
59.	46.	33.	24.	17.	13.	9.	7.	5.	4.
3.	2.	1.	1.	0.					

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.15	1	.00	.00	.00	1.	1.02	.15	97	.04	.04	.00	10.
1.01	.30	2	.00	.00	.00	1.	1.02	.30	98	.04	.04	.00	13.
1.01	.45	3	.00	.00	.00	1.	1.02	.45	99	.04	.04	.00	20.
1.01	1.00	4	.00	.00	.00	1.	1.02	1.00	100	.04	.04	.00	29.
1.01	1.15	5	.00	.00	.00	2.	1.02	1.15	101	.04	.04	.00	39.
1.01	1.30	6	.00	.00	.00	2.	1.02	1.30	102	.04	.04	.00	49.
1.01	1.45	7	.00	.00	.00	2.	1.02	1.45	103	.04	.04	.00	57.
1.01	2.00	8	.00	.00	.00	3.	1.02	2.00	104	.04	.04	.00	63.
1.01	2.15	9	.00	.00	.00	3.	1.02	2.15	105	.04	.04	.00	68.
1.01	2.30	10	.00	.00	.00	3.	1.02	2.30	106	.04	.04	.00	71.
1.01	2.45	11	.00	.00	.00	3.	1.02	2.45	107	.04	.04	.00	73.
1.01	3.00	12	.00	.00	.00	3.	1.02	3.00	108	.04	.04	.00	75.
1.01	3.15	13	.00	.00	.00	3.	1.02	3.15	109	.04	.04	.00	76.
1.01	3.30	14	.00	.00	.00	3.	1.02	3.30	110	.04	.04	.00	77.
1.01	3.45	15	.00	.00	.00	3.	1.02	3.45	111	.04	.04	.00	78.
1.01	4.00	16	.00	.00	.00	3.	1.02	4.00	112	.04	.04	.00	78.
1.01	4.15	17	.00	.00	.00	3.	1.02	4.15	113	.04	.04	.00	79.
1.01	4.30	18	.00	.00	.00	3.	1.02	4.30	114	.04	.04	.00	79.
1.01	4.45	19	.00	.00	.00	3.	1.02	4.45	115	.04	.04	.00	79.
1.01	5.00	20	.00	.00	.00	3.	1.02	5.00	116	.04	.04	.00	80.
1.01	5.15	21	.00	.00	.00	3.	1.02	5.15	117	.04	.04	.00	80.
1.01	5.30	22	.00	.00	.00	3.	1.02	5.30	118	.04	.04	.00	80.
1.01	5.45	23	.00	.00	.00	3.	1.02	5.45	119	.04	.04	.00	80.
1.01	6.00	24	.00	.00	.00	3.	1.02	6.00	120	.04	.04	.00	80.
1.01	6.15	25	.02	.01	.01	3.	1.02	6.15	121	.20	.19	.01	84.
1.01	6.30	26	.02	.01	.01	4.	1.02	6.30	122	.20	.19	.01	97.
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1.01	7.30	30	.02	.01	.01	9.	1.02	7.30	126	.20	.19	.00	243.
1.01	7.45	31	.02	.01	.01	10.	1.02	7.45	127	.20	.19	.00	277.
1.01	8.00	32	.02	.01	.01	11.	1.02	8.00	128	.20	.19	.00	302.
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1.01	9.15	37	.02	.01	.01	13.	1.02	9.15	133	.20	.19	.00	356.
1.01	9.30	38	.02	.01	.01	13.	1.02	9.30	134	.20	.19	.00	360.
1.01	9.45	39	.02	.01	.01	14.	1.02	9.45	135	.20	.19	.00	363.
1.01	10.00	40	.02	.01	.01	14.	1.02	10.00	136	.20	.19	.00	365.
1.01	10.15	41	.02	.01	.01	14.	1.02	10.15	137	.20	.19	.00	367.
1.01	10.30	42	.02	.01	.01	14.	1.02	10.30	138	.20	.19	.00	369.
1.01	10.45	43	.02	.01	.01	14.	1.02	10.45	139	.20	.19	.00	370.
1.01	11.00	44	.02	.01	.01	15.	1.02	11.00	140	.20	.19	.00	370.
1.01	11.15	45	.02	.01	.01	15.	1.02	11.15	141	.20	.19	.00	371.
1.01	11.30	46	.02	.01	.01	15.	1.02	11.30	142	.20	.19	.00	372.
1.01	11.45	47	.02	.01	.01	16.	1.02	11.45	143	.20	.19	.00	372.
1.01	12.00	48	.02	.01	.01	16.	1.02	12.00	144	.20	.19	.00	373.
1.01	12.15	49	.05	.03	.02	17.	1.02	12.15	145	.66	.66	.01	394.
1.01	12.30	50	.05	.03	.02	19.	1.02	12.30	146	.66	.66	.01	425.

Input Data
Various PMF Events
Desoto Pit and Plant A
MO 30468

1.01	12.45	51	.05	.03	.02	23.	1.02	12.45	147	.66	.66	.00	510.
1.01	13.00	52	.05	.04	.02	30.	1.02	13.00	148	.66	.66	.00	631.
1.01	13.15	53	.06	.04	.02	37.	1.02	13.15	149	.80	.79	.00	766.
1.01	13.30	54	.06	.04	.02	45.	1.02	13.30	150	.80	.79	.00	903.
1.01	13.45	55	.06	.05	.02	53.	1.02	13.45	151	.80	.79	.00	1039.
1.01	14.00	56	.06	.05	.01	60.	1.02	14.00	152	.80	.79	.00	1147.
1.01	14.15	57	.08	.06	.02	67.	1.02	14.15	153	.99	.99	.00	1245.
1.01	14.30	58	.08	.06	.02	74.	1.02	14.30	154	.99	.99	.00	1338.
1.01	14.45	59	.08	.06	.01	81.	1.02	14.45	155	.99	.99	.00	1434.
1.01	15.00	60	.08	.06	.01	88.	1.02	15.00	156	.99	.99	.00	1530.
1.01	15.15	61	.09	.06	.01	95.	1.02	15.15	157	1.01	1.01	.00	1618.
1.01	15.30	62	.16	.13	.02	103.	1.02	15.30	158	2.02	2.01	.00	1723.
1.01	15.45	63	.43	.38	.05	122.	1.02	15.45	159	5.64	5.64	.01	1974.
1.01	16.00	64	.11	.10	.01	152.	1.02	16.00	160	1.41	1.41	.00	2399.
1.01	16.15	65	.07	.06	.01	193.	1.02	16.15	161	.93	.93	.00	2979.
1.01	16.30	66	.07	.07	.01	226.	1.02	16.30	162	.93	.93	.00	3424.
1.01	16.45	67	.07	.07	.01	237.	1.02	16.45	163	.93	.93	.00	3559.
1.01	17.00	69	.07	.07	.01	232.	1.02	17.00	164	.93	.93	.00	3451.
1.01	17.15	69	.06	.05	.00	216.	1.02	17.15	165	.73	.73	.00	3183.
1.01	17.30	70	.06	.05	.00	192.	1.02	17.30	166	.73	.73	.00	2815.
1.01	17.45	71	.06	.05	.00	170.	1.02	17.45	167	.73	.73	.00	2470.
1.01	18.00	72	.06	.05	.00	153.	1.02	18.00	168	.73	.73	.00	2215.
1.01	18.15	73	.01	.00	.00	139.	1.02	18.15	169	.07	.06	.00	2002.
1.01	18.30	74	.01	.00	.00	125.	1.02	18.30	170	.07	.06	.00	1785.
1.01	18.45	75	.01	.00	.00	108.	1.02	18.45	171	.07	.06	.00	1541.
1.01	19.00	76	.01	.00	.00	90.	1.02	19.00	172	.07	.06	.00	1279.
1.01	19.15	77	.01	.00	.00	72.	1.02	19.15	173	.07	.06	.00	1026.
1.01	19.30	78	.01	.00	.00	57.	1.02	19.30	174	.07	.06	.00	801.
1.01	19.45	79	.01	.00	.00	44.	1.02	19.45	175	.07	.06	.00	614.
1.01	20.00	80	.01	.00	.00	34.	1.02	20.00	176	.07	.06	.00	478.
1.01	20.15	81	.01	.00	.00	27.	1.02	20.15	177	.07	.06	.00	382.
1.01	20.30	82	.01	.00	.00	22.	1.02	20.30	178	.07	.06	.00	312.
1.01	20.45	83	.01	.00	.00	19.	1.02	20.45	179	.07	.06	.00	261.
1.01	21.00	84	.01	.00	.00	16.	1.02	21.00	180	.07	.06	.00	224.
1.01	21.15	85	.01	.00	.00	14.	1.02	21.15	181	.07	.06	.00	196.
1.01	21.30	86	.01	.00	.00	13.	1.02	21.30	182	.07	.06	.00	175.
1.01	21.45	87	.01	.00	.00	11.	1.02	21.45	183	.07	.06	.00	159.
1.01	22.00	89	.01	.00	.00	11.	1.02	22.00	184	.07	.06	.00	148.
1.01	22.15	89	.01	.00	.00	10.	1.02	22.15	185	.07	.06	.00	142.
1.01	22.30	90	.01	.00	.00	10.	1.02	22.30	186	.07	.06	.00	137.
1.01	22.45	91	.01	.00	.00	10.	1.02	22.45	187	.07	.06	.00	133.
1.01	23.00	92	.01	.00	.00	9.	1.02	23.00	188	.07	.06	.00	131.
1.01	23.15	93	.01	.00	.00	9.	1.02	23.15	189	.07	.06	.00	129.
1.01	23.30	94	.01	.00	.00	9.	1.02	23.30	190	.07	.06	.00	127.
1.01	23.45	95	.01	.00	.00	9.	1.02	23.45	191	.07	.06	.00	126.
1.02	0.	96	.01	.00	.00	9.	1.03	0.	192	.07	.06	.00	126.
									SUM	36.40	35.64	.76	68257.
										(925.11	905.11	19.11	1932.821

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3559.	2001.	670.	355.	68192.
CMS	101.	57.	19.	10.	1931.
INCHES		24.82	33.23	35.24	35.24
MM		630.35	844.01	895.14	895.14
AC-FT		992.	1324.	1409.	1409.
THOUS CU M		1224.	1639.	1738.	1738.

Input Data
Various PMF Events
Desoto Pit and Plant A
MO 30468

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2
				RATIOS APPLIED TO FLOWS	
				.50	1.00
HYDROGRAPH AT	INFLOW	.75	1	1779.	3554.
		1.941		50.391	100.771
ROUTED TO	DAM	.75	1	1487.	3093.
		1.941		42.111	87.591

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	858.00	858.00	858.00
	STORAGE	2569.	2569.	2569.
	OUTFLOW	0.	0.	0.

	RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
Max. Velocity 4.6 5.8	.50	859.00	1.00	2916.	1487.	48.00	41.50	0.
	1.00	859.99	1.99	2905.	3093.	48.00	41.29	0.

Output Summary
Various PMF Events
Desoto Pit and Plant A